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Bangladesh: The Foodgrain Outlook Through 1985 Jan 75 ER RP 75-01


# *Bangladesh: The Foodgrain Outlook Through 1985*

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# BANGLADESH: THE FOODGRAIN OUTLOOK THROUGH 1985

## OBJECTIVES

1. The objectives of this publication are to assess past and prospective Bangladesh agricultural development and, on the basis of this assessment, to forecast the probable 1985 gap between foodgrain production and requirements.

## CONCLUSIONS

2. Agriculture in what is now Bangladesh responded favorably during the 1960s when the Pakistan government increased investment in its east wing. Peak foodgrain production rose from 8.4 million metric tons during the 1950s to 12.1 million tons in FY 1970.[1] After severe setbacks in foodgrain production as a result of natural disasters and the civil war, foodgrain production in FY 1974 recovered to its FY 1970 level. Imports declined to 2.1 million tons from a high of 2.9 million tons in FY 1973.

3. Dacca will have to give agriculture much more attention if the 3.4% annual growth rate of foodgrain production in the 1960s is to be reestablished. An even more rapid rate of growth must be attained in order to keep the gap between demand and domestic production from widening over the next decade.

4. The pressure of population growth on Bangladesh's agricultural resources shows no signs of abating. Death rates have fallen sharply, and family planning measures have had virtually no impact. Budgetary support for birth control programs is weak. Demographers foresee little change in the birth rate and predict that the 1974 population of 81 million will increase to nearly 115 million in 1985.

5. Bangladesh has the potential for substantially raising agricultural production. For example, irrigation can add six million acres to planted area in the dry season; less than 15% of cultivated land is under high yielding varieties (HYV) of grains; and utilization of fertilizers and pesticides is minimal.

1. The Bangladesh fiscal year ends on 30 June of the stated year.

Note: Comments and queries regarding this publication are welcomed. They may be directed to [redacted] of the Office of Economic Research, Code 143, Extension 6653. STATINTL

the growing demands of its population, Dacca must formulate major corrective programs and persevere in their execution. Areas requiring emphasis include the following:

- Reduction in the population growth rate through vigorous family planning programs.
- Accelerated development of intensive irrigation capable of supporting the multiple cropping of HYVs.
- Flood control to protect farmland and reduce the annual variation in rice production.
- Expanded production and improved distribution of HYV seeds, fertilizer, and other agricultural inputs.
- Increased rural institutional credit, with a larger share going to small farmers.

7. We believe that the government is unlikely to implement successfully programs that would significantly improve the rate of growth of foodgrain production. Bangladesh has governed itself only since 1971, and administrative experience is scarce. Numerous development projects are stagnating for lack of government guidance, even those fully financed by foreign funds. Barring an unforeseen change in government performance, the 1985 gap between production and domestic demand appears likely to fall within a range of 3 million to 4 million tons. The financing of imports to close the gap will continue to strain the nation's limited export capability.

## DISCUSSION

### Background

#### *The Agricultural Scene*

8. Agriculture is Bangladesh's most important economic activity, contributing about 60% of gross domestic product (GDP), compared with 9% for manufacturing. More than three-fourths of the people are farmers. Nonetheless, Bangladesh is unable to feed its 81 million people and requires imports of 10%

of total foodgrain consumed in normal years and up to 20% in poor years. Increasing domestic production is difficult and costly because all available land is already cultivated. Most farmers grow little more than enough to feed their own families. Production methods are primitive, farmers are burdened with debt, and yield per acre is among the lowest in the world. Poverty hinders the adopting of improved agricultural methods. Many seek not the largest crop but the surest one.

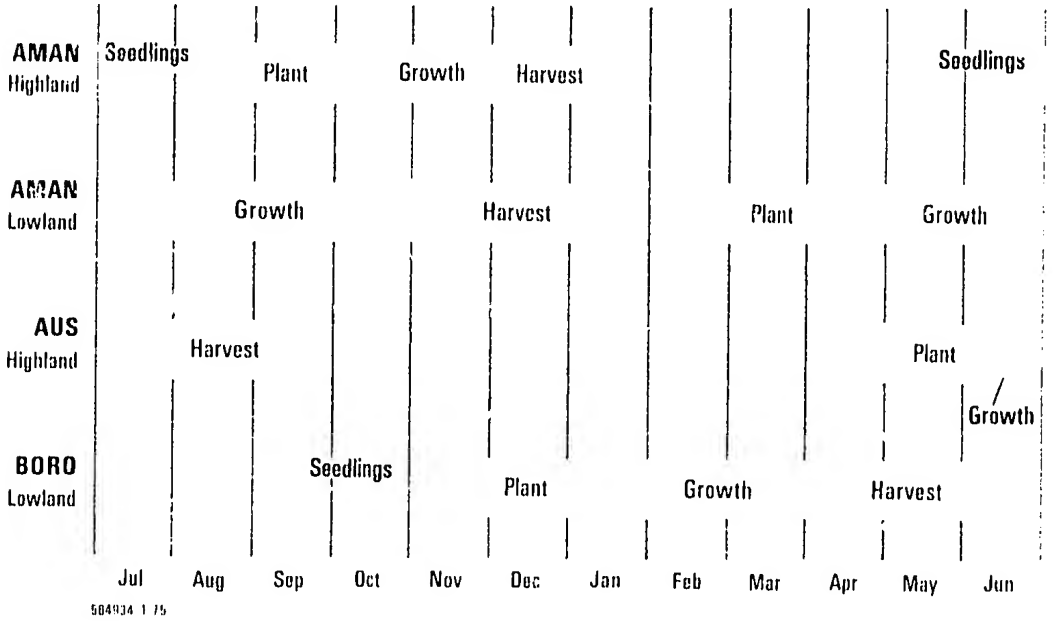
9. Rice is the mainstay of the diet and is grown almost to the exclusion of other cereals. Rice yields are largely influenced by the timing of rainfall and inundation. Two of the world's largest rivers, the Ganges and the Brahmaputra, flow through Bangladesh, and a third – the Meghna – flows from Assam the wettest part of India. The total annual flow of these rivers and their tributaries is twice that of the Mississippi. The summer monsoon deposits from 50 to 150 inches of rainfall, usually flooding about a one-third of the country and sometimes causing widespread crop and property damage. In October the rains stop, the land drains, and the rivers shrink. Generally, by February, drought conditions set in, and irrigation is required until May for crop growth. This hydrological cycle makes it necessary to use both flood control and irrigation systems to realize the region's agricultural potential.

10. The soil is fertile, and the climate permits plant growth throughout the year. There are three seasons a year in which rice can be cultivated, but they overlap to some extent so that the same land cannot carry all three crops. The three annual rice crops are (a) the ***aus*** harvest in July and August, (b) the ***aman*** harvest in November and December, and (c) the ***boro*** harvest in April and May (see the chart). They represent about 20%, 60%, and 20%, respectively, of rice output. The ***aman*** crop is grown practically throughout the country in both highlands and lowlands. It is sown earlier on lowlands to permit sufficient growth to withstand inundation by monsoon floods. The ***aus*** crop also is widespread, but has a shorter season and is limited to highlands to avoid monsoon flooding. The ***boro*** crop, grown during the dry season, is limited by irrigation requirements and is grown mainly in the marshy northeast.

### *The Human Environment*

11. The average land-owning villager possesses only 1.5 acres. He rents another acre from the well-to-do villagers and therefore cultivates 2.5 acres. This area is usually fragmented into six or more plots, some of which may be widely separated. He owns one scrawny bullock for plowing. The plow is a light 15-pound rig that turns only two or three inches of soil. The principal family resource is the rice

**BANGLADESH: Growing Seasons of Rice Crops**




kept for consumption, the product from about two acres. Since the usual rent of rice land is 50% of the crop, the average villager will get little more than enough produce to feed his family and finance a few purchases of clothing, cooking oil, etc. If he becomes indebted to moneylenders, he barely manages interest payments, and an occasional bad year puts him even deeper into debt.

12. The life of the one-tenth of the village laborers who are landless is even more grim. They are at the mercy of the landowners and are often evicted after a bad harvest. They earn two meals of rice and the equivalent of 25 cents to 35 cents a day during the peak of planting or harvesting season. In slack periods, hardly one in four will get a job, and even then for only 20 cents a day and no meals. During the slack season, therefore, the jobless often travel 100 miles or more to public construction projects providing some employment. At planting or harvesting time, they move back to their home areas.

*Production Since 1948*

13. Foodgrain output increased an average of 2.6% annually between FY 1948 and FY 1970, ending with peak output of 12.1 million tons in the last of those years (see Table 1). Most of the increase came during the 1960s, however, when output expanded at 3.4% per year, compared with virtual stagnation during the previous decade. Both acreage and yields expanded rapidly during the 1960s.

Table 1

Bangladesh: Foodgrain Production

Million Metric Tons

| Fiscal Year[1] | Rice | | | Wheat | Total[2] |
|---|---|---|---|---|---|
| | Aus | Aman | Boro | | |
| 1948 | 1.45 | 5.06 | 0.32 | 0.02 | 6.86 |
| 1949 | 1.43 | 6.09 | 0.27 | 0.02 | 7.82 |
| 1950 | 1.27 | 5.84 | 0.39 | 0.02 | 7.52 |
| 1951 | 1.82 | 5.36 | 0.28 | 0.02 | 7.48 |
| 1952 | 1.62 | 5.19 | 0.34 | 0.02 | 7.17 |
| 1953 | 1.68 | 5.41 | 0.36 | 0.02 | 7.48 |
| 1954 | 2.19 | 5.84 | 0.35 | 0.02 | 8.40 |
| 1955 | 1.99 | 5.35 | 0.37 | 0.03 | 7.74 |
| 1956 | 1.82 | 4.32 | 0.34 | 0.02 | 6.51 |
| 1957 | 2.19 | 5.88 | 0.24 | 0.02 | 8.34 |
| 1958 | 2.12 | 5.24 | 0.36 | 0.02 | 7.74 |
| 1959 | 1.59 | 5.05 | 0.40 | 0.03 | 7.06 |
| 1960 | 2.13 | 6.08 | 0.41 | 0.03 | 8.65 |
| 1961 | 2.54 | 6.68 | 0.46 | 0.03 | 9.70 |
| 1962 | 2.37 | 6.76 | 0.49 | 0.04 | 9.66 |
| 1963 | 2.24 | 6.14 | 0.49 | 0.04 | 8.91 |
| 1964 | 2.70 | 7.41 | 0.52 | 0.03 | 10.66 |
| 1965 | 2.54 | 7.38 | 0.58 | 0.03 | 10.53 |
| 1966 | 2.96 | 6.91 | 0.63 | 0.04 | 10.54 |
| 1967 | 2.69 | 6.01 | 0.84 | 0.06 | 9.61 |
| 1968 | 3.11 | 6.92 | 1.13 | 0.06 | 11.22 |
| 1969 | 2.73 | 6.98 | 1.64 | 0.09 | 11.44 |
| 1970 | 3.01 | 7.06 | 1.93 | 0.10 | 12.11 |
| 1971 | 2.91 | 6.01 | 2.23 | 0.11 | 11.26 |
| 1972 | 2.38 | 5.78 | 1.81 | 0.11 | 10.08 |
| 1973 | 2.31 | 5.68 | 2.10 | 0.09 | 10.18 |
| 1974[3] | 2.85 | 6.81 | 2.26 | 0.10 | 12.01 |

1. Ending 30 June of stated year.
2. Because of rounding, components may not add to the totals shown.
3. Preliminary.

Gains stemmed primarily from the expansion of irrigation that made possible the doubling of acreage in ***boro*** rice (see Table 2) and the introduction of HYV rice that doubled ***boro*** yields (see Table 3). Expansion of the ***aus*** and ***aman*** crops has been limited by inadequate control over monsoon flooding; HYV rice demands

Table 2

Bangladesh: Area Planted to Rice

Million Acres

| Fiscal Year[1] | Aus | Aman | Boro | Total[2] |
|---|---|---|---|---|
| 1948 | 4.90 | 13.35 | 0.76 | 19.01 |
| 1949 | 4.75 | 13.86 | 0.81 | 19.42 |
| 1950 | 4.67 | 14.01 | 0.84 | 19.53 |
| 1951 | 5.26 | 13.95 | 0.80 | 20.01 |
| 1952 | 5.45 | 14.03 | 0.83 | 20.30 |
| 1953 | 5.50 | 14.44 | 0.84 | 20.78 |
| 1954 | 6.32 | 14.85 | 0.84 | 22.01 |
| 1955 | 6.03 | 14.45 | 0.86 | 21.34 |
| 1956 | 5.82 | 12.99 | 0.69 | 19.49 |
| 1957 | 5.99 | 13.38 | 0.69 | 20.06 |
| 1958 | 5.79 | 13.63 | 0.82 | 20.24 |
| 1959 | 5.65 | 13.15 | 0.85 | 19.64 |
| 1960 | 5.95 | 14.29 | 0.92 | 21.15 |
| 1961 | 6.30 | 14.58 | 1.01 | 21.89 |
| 1962 | 5.87 | 14.08 | 1.01 | 20.96 |
| 1963 | 6.19 | 14.22 | 1.07 | 21.48 |
| 1964 | 6.59 | 14.60 | 1.07 | 22.26 |
| 1965 | 6.65 | 15.11 | 1.05 | 22.81 |
| 1966 | 7.32 | 14.67 | 1.14 | 23.13 |
| 1967 | 6.97 | 14.06 | 1.18 | 22.21 |
| 1968 | 8.22 | 14.68 | 1.53 | 24.44 |
| 1969 | 7.66 | 14.40 | 2.02 | 24.07 |
| 1970 | 8.46 | 14.84 | 2.16 | 25.49 |
| 1971 | 7.89 | 14.18 | 2.43 | 24.49 |
| 1972 | 7.42 | 13.00 | 2.20 | 22.62 |
| 1973 | 7.24 | 14.12 | 2.43 | 23.79 |
| 1974[3] | 7.68 | 14.13 | 2.66 | 24.47 |

1. Ending 30 June of stated year.
2. Because of rounding, components may not add to the totals shown.
3. Preliminary.

more precise water control than do traditional varieties. In FY 1972, HYV rice contributed 6%, 15%, and 52% of the rice output of the *aus*, *aman*, and *boro* crops, respectively.

14. In the early 1970s, rice production suffered a series of extraordinary setbacks – the cyclone of November 1970, the civil war of 1971, and a poor

Table 3

Bangladesh: Average Yield of Rice Crops

Pounds per Acre

| Fiscal Year[1] | Aus | Aman | Boro | Total |
|---|---|---|---|---|
| 1948 | 655 | 837 | 940 | 794 |
| 1949 | 664 | 969 | 739 | 885 |
| 1950 | 601 | 918 | 1,007 | 847 |
| 1951 | 762 | 847 | 783 | 822 |
| 1952 | 655 | 816 | 895 | 776 |
| 1953 | 674 | 826 | 940 | 790 |
| 1954 | 762 | 867 | 918 | 839 |
| 1955 | 726 | 816 | 962 | 796 |
| 1956 | 691 | 735 | 1,086 | 734 |
| 1957 | 807 | 969 | 772 | 914 |
| 1958 | 807 | 847 | 985 | 841 |
| 1959 | 619 | 847 | 1,029 | 789 |
| 1960 | 789 | 939 | 974 | 898 |
| 1961 | 888 | 1,010 | 996 | 974 |
| 1962 | 888 | 1,058 | 1,078 | 1,012 |
| 1963 | 797 | 952 | 1,007 | 910 |
| 1964 | 904 | 1,118 | 1,067 | 1,052 |
| 1965 | 843 | 1,077 | 1,221 | 1,615 |
| 1966 | 893 | 1,038 | 1,218 | 1,001 |
| 1967 | 851 | 943 | 1,576 | 948 |
| 1968 | 834 | 1,039 | 1,627 | 1,007 |
| 1969 | 785 | 1,069 | 1,792 | 1,039 |
| 1970 | 784 | 1,049 | 1,953 | 1,039 |
| 1971 | 813 | 934 | 2,024 | 1,003 |
| 1972 | 707 | 980 | 1,814 | 972 |
| 1973 | 703 | 887 | 1,905 | 935 |
| 1974[2] | 818 | 1,063 | 1,873 | 1,073 |

1. Ending 30 June of stated year.
2. Preliminary.

monsoon in 1973 -- but returned to pre-independence levels in FY 1974. The government places the FY 1974 rice crop at 11.9 million tons, but independent estimates range from 12.3 million to 12.5 million tons. Even the government's lower estimate represents an 18% increase over the preceding year. But with more mouths to feed, per capita production still has not recovered.

15. Rice production has been inadequate to feed the population since the 1930s. During the early 1950s, East Pakistan approached self-sufficiency in foodgrains, but again became a large importer by the end of the decade as population growth accelerated while rice production stagnated (see Table 4). Even when rice production began to increase during the 1960s, East Pakistan's foodgrain imports continued to rise.

Table 4

Bangladesh: Foodgrain Imports

Thousand Metric Tons

| Fiscal Year[1] | Rice | | | Wheat and Other Grains | | | All Food-grains |
|---|---|---|---|---|---|---|---|
| | West Pakistan | Other Countries | Total | West Pakistan | Other Countries | Total | |
| 1949 | 86 | 20 | 106 | N.A. | .... | N.A. | N.A. |
| 1950 | 119 | 43 | 162 | N.A. | .... | N.A. | N.A. |
| 1951 | 29 | .... | 29 | N.A. | .... | N.A. | N.A. |
| 1952 | 74 | .... | 74 | N.A. | .... | N.A. | N.A. |
| 1953 | 67 | .... | 67 | 10 | .... | 10 | 77 |
| 1954 | 49 | .... | 49 | 21 | .... | 21 | 70 |
| 1955 | 2 | .... | 2 | 17 | .... | 17 | 19 |
| 1956 | 12 | 55 | 67 | 31 | 9 | 40 | 107 |
| 1957 | 3 | 541 | 544 | 58 | 41 | 99 | 643 |
| 1958 | 134 | 421 | 555 | 27 | 100 | 127 | 682 |
| 1959 | 287 | 182 | 469 | 20 | 7 | 27 | 496 |
| 1960 | 83 | 360 | 443 | 33 | 148 | 181 | 624 |
| 1961 | 104 | 382 | 486 | 14 | 234 | 248 | 734 |
| 1962 | 22 | 203 | 225 | 37 | 195 | 232 | 457 |
| 1963 | 248 | 245 | 493 | 69 | 917 | 986 | 1,479 |
| 1964 | 187 | 143 | 330 | 9 | 657 | 666 | 996 |
| 1965 | 22 | 62 | 84 | 68 | 250 | 318 | 402 |
| 1966 | 278 | 48 | 326 | 23 | 529 | 552 | 878 |
| 1967 | 242 | 191 | 433 | 84 | 716 | 800 | 1,233 |
| 1968 | 166 | 150 | 316 | 25 | 674 | 699 | 1,015 |
| 1969 | 191 | 66 | 257 | 193 | 739 | 932 | 1,189 |
| 1970 | 410 | 120 | 530 | 163 | 930 | 1,093 | 1,623 |
| 1971 | 313 | 787 | 1,100 | 27[2] | 854 | 881 | 1,981 |
| 1972[2] | .... | 500 | 500 | .... | 1,350 | 1,350 | 1,850 |
| 1973 | .... | 385 | 385 | .... | 2,500[2] | 2,500 | 2,885 |
| 1974[2] | .... | 83 | 83 | .... | 2,000 | 2,000 | 2,083 |

1. Ending 30 June of stated year.
2. Estimated.

16. The 1974 monsoon has been heavy, bringing unusually severe flooding, especially in the eastern areas. A loss of about 800,000 tons from flooding normally is anticipated. Dacca's claim that this year's losses amounted to nearly 2 million tons is almost certainly exaggerated. In any case, the heavier rains increased yields in dryer areas, partly offsetting above-normal flood losses. The government is projecting FY 1975 foodgrain import requirements at 2.3 million tons.

*Government Policy*

17. In its First Five-Year Plan (FY 1974-78), Dacca has set a goal of foodgrain self-sufficiency by the last year of the plan. Rice production is to sustain a growth rate of more than 6% annually -- an unprecedented rate. In addition, wheat output is to grow 32% a year. To realize this rate of growth, Dacca is to undertake massive programs to expand irrigation, control flooding, increase HYV rice acreage, expand rural credit institutions, and improve availability of fertilizer, pesticides, and herbicides. One-fourth of the development budget has been allocated to agriculture and related sectors, compared with about one-third during the 1960s and in Bangladesh's first two annual plans. In real terms, the planned outlay for agriculture will be no larger than in previous plans, in which funding was considered inadequate. Considering the meager resources available and the problems confronting agriculture, Bangladesh will be fortunate if foodgrain production simply keeps pace with population growth and the foodgrain deficit does not increase.

18. The government maintains a costly and extensive foodgrain distribution system to assure minimum essential supplies to residents of four major cities and to poorer elements in other areas. Official foodgrain stocks are distributed through fair price shops -- specially licensed small private stores. Foodgrains and other essential commodities are sold to ration cardholders in fixed amounts and at set prices. Comprehensive statutory rationing exists in Dacca, Khulna, Chittagong, and Narayanganj, where varying supply conditions cause frequent changes in ration size. In August 1974 the ration was about 6 pounds of rice a week per adult. By mid-October 1974, it had been reduced to about 5 pounds. In other towns in food-deficit areas, only the poorer segment of the population is issued ration cards for subsidized foodgrain purchases. Substantial quantities of foodgrains also are provided free as relief in the event of natural calamities or acute economic distress. In recent years, the government has distributed the equivalent of 15% to 25% of domestic grain production.

19. Almost all grain for government distribution is imported. Although the government buys rice in local markets, mainly from the *aman* crop, acquisitions

have fallen short. From the last *aman* crop, the government's procurement target was 400,000 tons, but only 67,000 tons were obtained because prices offered by government agents were substantially below free market prices. The government's low procurement price for rice is not a disincentive to domestic production, however, because of the strong demand in the free market.

20. Agricultural inputs are also subsidized. In the Fifth Plan, 19% of the cost of all agricultural inputs distributed to farmers is to be subsidized by the government. Because the input program has a large foreign exchange component and receipts are in domestic currency, the real subsidy is substantially higher. Currently, subsidies amount to 60% for phosphates, 40% for potash, and 80% for irrigation pumps, whereas pesticides are usually distributed free.

21. Shortage of foodgrains is one of the major causes of Bangladesh's continuing inflation. The price of rice has doubled since independence, but rose only about 20% last year because of increased production. The government attempts to retard inflation by keeping ration shop prices artifically low. Nonetheless, ration prices for rice and wheat were increased 33% and 44%, respectively, last May. The government has committed itself to holding the general price rise in FY 1975 below 10%, but achievement of this goal is unlikely.

22. Because of the high price of rice in India and a black market currency exchange rate favoring the Indian rupee, there is smuggling of rice from Bangladesh to India. Informed estimates of its volume range from 200,000 tons to 500,000 tons annually. To combat smuggling, Dacca discontinued free trade with India in its border areas. Dacca requires also that the entire rice production from the husking mills within ten miles of the border be sold to the government. Enforcement is difficult, however.

### Factors Affecting Future Demand

23. While there is substantial disagreement on the size of its present population, there is no doubt that Bangladesh is the world's eighth most populous nation. Our estimate of population is based on several assumptions, all of them conservative:

- population as of July 1970: 73.3 million (range of estimates: 70.0 million to 77.5 million);
- population growth rate: 3.0% (range of estimates: 2.9% to 3.5%);

- fatalities in November 1970 cyclone: 300,000 (government of Pakistan estimate: 250,000) (Bangladesh claims of 500,000 appear inflated for political reasons);

- fatalities in war for independence: 1.5 million (Bangladesh claims of 3 million appear inflated for political reasons); and

- war refugee exodus to India – all forced to return.

On the basis of these assumptions, we estimate Bangladesh's mid-1974 population at 81 million.

24. Dacca estimates present annual population growth at 3.09% and hopes to reduce the rate substantially by 1985. Most demographers believe that present annual population growth is closer to 3.3% and that only a marginal reduction in the rate is possible by 1985, especially since nearly one-half of the population is less than 15 years old. If population grew at 3.09% per year, it would reach 113 million in mid-1985. At a constant 3.3% per year, population would reach 115 million. There is no precedent for a population of this magnitude living in an essentially rural environment in an area the size of Louisiana.

25. Dacca has a small family planning program, but admits that almost nothing has been accomplished since independence. Many Bengalis considered the pre-independence government's emphasis of family planning a political weapon intended to reduce East Pakistan's population relative to that of West Pakistan. Not only are present government birth control programs insufficient, but also the pre-conditions for their success do not yet exist. Although religion is not an obstacle to birth control, tradition and economics are. A large family is a form of social security, and parents, aware of the high rate of child mortality, continue to have children until at least one son grows to manhood. The low level of literacy and economic development also hampers the success of any birth control program. These conditions are not likely to change rapidly in Bangladesh, where more than 90% of the population lives in rural areas and is engaged principally in subsistence agriculture.

26. The current level of food consumption is minimal, and the quality of the average diet is very poor. Malnutrition is endemic. While most of the rural population subsists on what it grows, the average urban wage earning family spends about two-thirds of its budget on food. Consumption of leafy vegetables and meat is low, but abundant fish provide some protein. In most homes, only nonperishable

foodstuffs can be stored. Thus, foodgrains account for some three-fourths of the calories and 70% of the protein in the diet. Because there is little margin for decreasing per capita consumption, declines in foodgrain availability can quickly become disastrous.

27. In general, Bangladesh's population can be considered immobile, but the few cities provide a strong attraction for the rural population. When rural areas are hit by drought, flood, or cyclone, the flow to the cities becomes a torrent. The populations of Bangladesh's three largest cities have risen rapidly since 1961: Dacca's by 193%, Khulna's by 439%, and Chittagong's by 139%. Despite rapid expansion, less than 10% of the population lives in urban areas. There is also some illegal migration to India. Although a headache for India, migrations since independence have been far less than during some years in the 1960s.

28. The continuing migration to the cities complicates the feeding and employment of the population. The government pays a disproportionate amount of attention to its urban populations, partly because of their great density and partly because city dwellers are often more sophisticated and politically active. Low incomes and high unemployment make the cities potential trouble spots. To feed large urban populations requires complex food distribution systems, unnecessary in rural areas.

29. Future demand for foodgrain is also affected by the price and income elasticities -- the degree to which changes in the price of foodgrains and average income will affect demand. Two factors led to the exclusion of price elasticity from consideration:

- Because foodgrains make up such a large part of the diet and substitutes are scarce, it is reasonable to assume that price elasticity of demand is low.

- There is no reliable method for predicting changes in Bangladesh's price structure over the next decade. It is therefore assumed to remain basically unchanged.

30. The income elasticity of demand for foodgrains, on the other hand, cannot be ignored, because per capita income levels probably will change significantly over the next decade. Sample measurements of income elasticity in Bangladesh in the period FY 1967-69 by the Harvard University Center for Population Studies, using several methods of calculation, range from 0.32 to 0.40.

(An income elasticity of 0.35 means that for each 1% increase in per capita income, the demand for foodgrains would increase 0.35%.)

**Factors Affecting Future Supply**

***Weather and Climate***

31. Rainfall and flooding are the dominant influences on foodgrain production. Rainfall changes during any one year can drop foodgrain output by 10% or more. Likewise, highly favorable weather raises output rapidly. Nevertheless the lack of reliable long-range weather forecasting techniques requires that output projections assume normal or average weather. Climatologists are developing long-range forecast techniques, but none is sufficiently advanced to be reliably applied to Bangladesh.

32. The annual monsoonal flood is also a determinant of foodgrain production. Two-thirds of the cultivated area is inundated to a depth of more than one foot, one-third to a depth of three feet, and about 15% to a depth of more than six feet. Villagers are accustomed to such flooding, and their crops are adapted to it. The uncertainties of timing, duration, extent, and depth of floods result in considerable crop losses, however, as well as in property damage. Early floods ruin young rice plants in the fields or destroy seed beds. If the flood is late and persists while the rice is in flower, yields fall sharply. Floods usually rise and fall quickly, but if they stand more than four days, many rice plants are destroyed. If the flood is too deep, short-stemmed rice plants, even on relatively high ground, will drown. If the flood is not deep enough, rice on the high ground will not get sufficient moisture.

33. Cyclonic storms are another threat, sometimes more damaging than the annual floods. Tropical storms moving up the Bay of Bengal frequently batter the coastal regions, and the flat delta terrain is defenseless against the tidal waves that often accompany them. The strong winds and heavy rains can flatten rice fields for 50 to 100 miles inland. Crop damage and loss of life caused by cyclones has worsened as population pressure forces more people into the vulnerable coastal area.

34. Bangladesh's flat terrain precludes development of large storage reservoirs for controlling the impact of the floods and/or retaining water for irrigation in the dry season. Flood control efforts have been restricted to extensive systems of embankments. The lack of rock and clay fill makes their construction and

maintenance difficult and costly. The area protected by embankments in FY 1973 was 3 million acres, including land protected from saline water inundation through coastal embankments. The Fifth Plan calls for the completion of another embankment scheme to protect an additional 2 million acres by the end of FY 1978.

*Irrigation*

35. Expansion of all forms of irrigation is essential to increasing the area under cultivation and improving yields. While virtually all arable land is already cultivated, only 35% is cropped more than once a year. The climate is amenable to year-round plant growth, however, and labor for intensive cultivation is abundant.

36. The Fifth Five-Year Plan emphasizes development of irrigation. The plan target is to have 6.15 million acres of rice irrigated by modern methods by FY 1978, with gross irrigated area[2] rising from an FY 1973 level of 1.27 million acres to about 4.13 million acres (see Table 5). IBRD specialists, however, believe the FY 1978 goal will not be attainable before the early 1980s. Plan data exclude acreage irrigated by traditional methods, such as wells drawn by hand or bullock that in FY 1970 amounted to 1.44 million acres. The area irrigated by such methods should gradually decline as more modern methods are introduced.

Table 5

Bangladesh: Gross Irrigated Area[1]

Thousand Acres

| Type of Irrigation | FY 1970 | FY 1973 | Plan Target FY 1978 |
|---|---|---|---|
| Total | 837 | 1,266 | 4,132 |
| Government programs | | | |
| Low-lift pumps | 639 | 1,050 | 2,250 |
| Deep tubewells | 85 | 70 | 1,144 |
| Shallow tubewells | .... | 16 | 225 |
| Major projects | 100 | 80 | 463 |
| Private investment | 13 | 50 | 50 |

1. Irrigated acreage that supports more than one crop per year is counted once for each crop. Areas irrigated by traditional primitive means, which amounted to 1.44 million acres in FY 1970, are excluded.

2. Gross irrigated area counts double-cropped acreage once for each crop.

37. Monsoonal floods make expansion of acreage during the summer season possible only through extensive flood control and drainage facilities. Such projects are costly and require long leadtimes. For these reasons, only 45% of the funding for water control is for pump and tubewell installations, from which more than 85% of irrigation gains in the current five-year plan are to be derived.

38. Groundwater is abundant, but its utilization has lagged, largely because fragmentation of holdings inhibits the effective use of low-lift pumps and tubewells. For tubewells and pumps to be profitable, they generally must irrigate at least 10 acres. Few rice farmers cultivate plots that large, or have the funds and willingness to consolidate with neighbors. Few attempts to organize cooperatives have succeeded. Although the pace of groundwater development quickened following the introduction of HYV rice in the mid-1960s, by 1970, only one-seventh of the 7 million acres suitable for production during the dry season *boro* crop were irrigated.

*Low-Lift Pumps*

39. Low-lift pump installations have been the most effective form of irrigation introduced and are expected to continue leading the way. They are small pumps -- usually with a capacity of two cubic feet per second (cusec) -- used to raise water from perennial streams and ponds primarily during the winter season. The number of such pumps has mushroomed from about 1,400 in FY 1961 to more than 32,900 in FY 1973. During that period, the acreage irrigated per pump declined as more were distributed to individual farmers and relatively fewer to cooperative pump groups. Data on government-distributed pumps indicate that the number of acres irrigated per unit of pump capacity dropped from 38 in 1961 to 20 in 1973. These data are inflated, however, especially for the later years, because individual farmers strengthened their applications for pumps by exaggerating prospective benefits. Independent surveys suggest that current acreage irrigated per cusec of capacity is on the order of 7 to 12. The Fifth Plan projects an increase in efficiency to 25 acres per cusec and an increase in pumps to 45,000 by FY 1978. The efficiency goal is unrealistic in that heavy subsidization (80%) decreases the incentive for efficient use.

*Tubewells*

40. By FY 1973, some 2,565 deep tubewells[3] had been installed through public sector programs, with a total command area of about 200,000 acres.

3. Deep tubewells are those made from largely imported technologically complex pumps and engines, of two cusecs or more capacity and sunk by power rigs. Shallow tubewells are made of pumps and engines of largely local construction involving a simple technology, with less than one cusec capacity and sunk by labor-intensive methods.

According to the IBRD, actual irrigated acreage, however, was only about 70,000 acres. Repair and maintenance have been major problems. Although extensive groundwater surveys are yet to be carried out, an estimated 4 million acres have good potential for irrigation by tubewells. During the Fifth Plan, some 16,000 deep tubewells are to be installed, and the area under deep tubewell irrigation is expected to increase to 1.1 million acres. The targets seem overly ambitious. During FY 1973, for example, out of a target of 2,400 deep tubewells to be installed, only 744 were sunk and only 104 of those were commissioned.

41. Shallow tubewells are relatively cheap and easier to install than deep tubewells. Because they irrigate only 7-15 acres, organizing farmers to use them effectively is simpler. Installations, nevertheless, have lagged behind expectations. Out of an FY 1973 target of 2,000 wells, about 1,000 were drilled and only 153 commissioned. Maintenance is a major problem so that many are out of service for extended periods. During the Fifth Plan, the government intends to install 15,000 shallow tubewells, raising the area they irrigate to 225,000 acres.

*Large-Scale Projects*

42. Major programs for embankment construction and related flood-control measures, channel improvement, and gravity-induced irrigation have been under the aegis of the Bangladesh Water and Power Development Authority (BWPDA). Its projects have a history of cost and term overruns and have only moderately improved rice production.

43. The largest BWPDA project, Ganges-Kobadak, Phase I, was designed to irrigate 350,000 acres at a cost of $10.5 million. Nearly 20 years later and 10 years behind schedule, it irrigates less than 70,000 acres, continues to be plagued by major problems, and has cost more than $130 million. The Dacca-Demura project, irrigating about 10,000 acres, has been somewhat more successful. The Fifth Plan projects an increase in gross area irrigated by large-scale projects to 463,000 acres by FY 1978. In view of the long leadtimes required, the country's lack of resources, and rapidly rising costs, attainment of half of this goal will be a good achievement.

44. Moreover, Indian plans for fluvial development will significantly affect Bangladesh because its major rivers emanate from India. India's Farakka Barrage, for example, which is expected to come into operation by the end of 1974, could withdraw some 40,000 cusecs from the Ganges to flush out the port of Calcutta. Withdrawal of this volume during the dry season would leave very little water

for Bangladesh. Extravagant Indian use of Ganges waters would reduce irrigation, inland water transport, and fishing along the Bangladesh portion of the river and increase salt water intrusion, damaging currently productive croplands. Because there is a pressing need to expand irrigation in India, heightened tension between India and Bangladesh over riparian rights can be expected.

*Agricultural Inputs*

45. Accelerating foodgrain output depends heavily on raising rice yields by increased use of HYVs, fertilizer, and pesticides. The potential for raising yields of traditional varieties is quite limited. The latter are relatively tall, weak-stemmed plants. Abundant application of fertilizer produces heavier heads, causing the plants to fall over or lodge. Increased rice yields, therefore, require a major modification in rice cultivation.

46. HYV rice, originally developed by the International Rice Research Institute in the Philippines, has shorter and stronger stems capable of supporting much larger heads. With proper care, yields double those of traditional varieties are common. HYV rice opens up enormous production possibilities but requires difficult adjustments in institutions and cultural practices if the full benefits are to be realized. Pest and weed control, better land preparation, controlled irrigation, proper timing in transplanting, and appropriate use of fertilizers are all necessary to take advantage of the new technology. This implies a heavy burden on research, extension, educational, and credit services.

47. Continuing development is essential to the adaption of HYVs to local conditions. An original HYV rice, IR8, introduced in 1966 for use in the *boro* and *aus* crops, was not popular because of poor taste, unsatisfactory milling qualities, susceptibility to local diseases, and a relatively long growing period that did not easily fit into normal seasonal cultivation patterns. The newer IR20, introduced in 1970, overcame most of these difficulties. IR20's short growing period increases the possibilities for double and triple cropping. On the negative side, IR20 can only withstand inundations of up to one foot and therefore is unsuitable for growth during the monsoon season, except in relatively high areas. Despite encouraging results, especially in the *boro* crop, adoption has been slow because of the civil war and the persisting economic dislocations.

48. The Bangladesh Rice Research Institute (BRRI) near Dacca is adapting HYVs for domestic use. Technical and material assistance is being provided by the International Rice Research Institute in the Philippines, and the Ford

Foundation is giving financial support. BRRI has developed a new strain with improved resistance to disease and pests to replace IR8 and is in the advanced stages of developing a flood-resistant substitute for IR20.

*Seeds*

49. Traditionally, farmers have reseeded with stock retained from their previous crop or purchased from neighbors. The introduction of HYV rice forced the development of a different distribution system. Because yields of HYV rice decline when reseeded from field stock, seeds should be replenished from seed farms at least every four years.

50. The Bangladesh Agricultural Development Corporation (BADC), which has primary responsibility for procuring, multiplying, processing, and distributing rice seeds, is seriously deficient. As local research develops new HYVs adapted for conditions in Bangladesh, BADC seed farms must produce enough seed stock for domestic use. In FY 1973, however, 60% of the seed distributed by BADC was imported, mostly the IR20 variety. Furthermore, the quality of seed released by the BADC has been so poor that farmers do not trust it. A National Seeds Board and a Seeds Certification Agency are being established, and a new rice seed project, designed to overcome some of the problems in the present system, is under way with IDA financing.

51. HYV rice seeds are sold to farmers at half their production cost. Demand has been so strong, however, that the heavy subsidy appears to be an unnecessary encouragement to promote the adoption of HYV rice. The government, therefore, plans to reduce these subsidies on a phased basis during the Fifth Plan.

*Fertilizers*

52. Use of manufactured fertilizer in Bangladesh has always been extremely limited. Silt deposited by the annual floods has kept the land fertile despite centuries of extensive cropping. But production can be greatly enhanced by fertilizers, and proper fertilization is essential if the potential of HYV rice is to be realized. In recent years the average fertilizer dose has been 10 pounds of nutrient per acre -- less than 5% of the recommended level.

53. Fertilizer use has grown rapidly over the past 15 years. Despite a doubling of fertilizer prices, fertilizer consumption rose to 381,000 tons in FY 1973, a 35% increase over 1970 (see Table 6). The Fifth Five-Year Plan projects a tripling

Table 6

Bangladesh: Distribution of Fertilizers

Thousand Metric Tons

| | FY 1965 | FY 1970 | FY 1973 | Target FY 1974 | Fifth Plan Target FY 1978 | IBRD Projection FY 1978 |
|---|---|---|---|---|---|---|
| Total[1] | 96 | 282 | 381 | 473 | 1,153 | 871 |
| Urea | 72 | 206 | 274 | 278 | 626 | 592 |
| TSP | 19 | 67 | 89 | 156 | 337 | 226 |
| MP | 4 | 16 | 18 | 39 | 190 | 53 |
| In terms of nutrients | 45 | 132 | 174 | 219 | 547 | 400 |

1. Because of rounding, components may not add to the totals shown.

of fertilizer consumption; a doubling of fertilizer consumption during this period would be a major achievement.

54. Domestic plants can produce two of the three fertilizers applied to rice in Bangladesh -- urea and triple super-phosphate (TSP) -- but not muriate of potash (MP). Domestic productive capacity exceeds current levels of fertilizer consumption, but technical and supply problems have hampered production, necessitating imports. Urea is produced from abundant domestic sources of natural gas at two plants, Fenchuganj with a rated capacity of 100,000 tons and Ghorasal with a rated capacity of 340,000 tons. The latter, a new plant, will be kept out of operation for at least a year by an explosion that occurred in September 1974. A third urea plant, financed by the World Bank, USAID, and others, is to add 450,000 tons to capacity by 1978. Two phosphate plants have a combined capacity of 150,000 tons but have been stymied by a world shortage of rock phosphate.

55. Despite the strength and resilience of fertilizer demand during recent years, the government continues to subsidize fertilizer sales. World prices for fertilizer rose dramatically during 1973 and early 1974, but domestic prices remained fixed, requiring rapid increases in subsidies and imposing a major drain on financial resources. In April 1974 the government raised the price of urea by 67% and doubled the prices of TSP and MP. Government subsidy levels, as a percent of the world market price, during the last two years are shown in the accompanying tabulation. The new urea price more than covers the delivered cost of locally

| | Percent | | |
|---|---|---|---|
| | Urea | TSP | MP |
| FY 1973 | 19 | 57 | 55 |
| FY 1974 | -16 | 60 | 40 |

produced urea, but it is about 38% below costs for imported urea. In effect, the new prices tax domestically produced urea to subsidize imported fertilizers.

56. Fertilizer imports have been increasing steadily. All MP and TSP is imported at present. While some TSP will probably be produced in FY 1975, TSP imports should continue to rise. Urea imports were cut drastically in FY 1974 when the Ghorasal plant started production. With Ghorasal now shut down, urea imports will rise again. Even if Five-Year Plan targets are met, Bangladesh will still have to import all of its MP, one-half of its urea, and three-fourths of its TSP in FY 1978.

57. Despite subsidized imports, fertilizers are generally in short supply and are traded in black markets at up to three times the official price. Transport and marketing deficiencies, as well as smuggling to India, exacerbate the basic imbalance between supply and demand.

*Pesticides*

58. Pesticides can greatly reduce crop losses to insects that flourish in the hot and humid climate. With HYV rice, the returns from protective measures increase significantly. Protected acreage increased from about 0.3 million spray acres[4] in FY 1960 to about 10.0 million spray acres in FY 1970 and to 11.6 million in FY 1973. The Fifth Plan calls for a tripling in pesticides consumption by FY 1978.

59. Pesticides are provided free. Charges of up to 50% of the cost have been considered but put off for political reasons. Because they cost nothing, the chemicals frequently are wasted or misused. Insufficient consumer education and the confusing variety of pesticides provided – about 36 different types, each in several concentrations – also contribute to misuse. Inappropriate spraying has destroyed crops, decimated fish populations, and caused deaths in farm families.

***Institutional Barriers***

60. The average farm size in Bangladesh is about 2.5 acres. Only 4% of the cultivated land is on farms of 25 acres or larger. Thus, in the Bangladesh context, a 10-acre farm is very large. On the other hand, only about 10% of rural households are landless. For a land-poor country, the ratio of landless to landed households is strikingly low.

4. Spray acreage includes much double counting because many plots are sprayed two and three times.

61. Distribution of ownership is not a good measure of the average size of a farmed plot, however, because, as of 1960, 96% of all farm land was held in fragmented holdings. More than one-half of the farms are made up of at least six separate plots, and one-third have more than 10 plots. These plots rarely are contiguous. Often they are a mile or more apart. Land reform under such circumstances would be a horrendous task. Moreover, most farmers are believed likely to resist change in traditional landholding patterns.

62. The availability of credit in rural areas is inadequate. More than one-half of the rural credit appears to support current consumption rather than agricultural production. Institutional credit provides only about 15% of the average farmer's borrowings, about one-half comes from relatives and friends, and 35% from moneylenders and traders.

63. The introduction of new rice varieties and the accompanying increased requirement for agricultural inputs have increased the strain on institutional credit facilities. Consequently, the government is attempting to expand credit institutions in rural areas. During the Fifth Plan, institutional agricultural credit is targeted to increase from present levels of around 300 million takas[5] to more than 1.6 billion takas, and the loan recovery rate is to rise from a present level of about 50% to 90%. Both targets are unrealistic. Agricultural credit institutions are for the most part in severe financial trouble. No provision is made in the revenue budget to guarantee the volume of lending proposed under the Fifth Plan. Budgetary support is essential because the low interest rates on agricultural loans do not reflect actual costs and risks.

64. The administrative capacity to cope with such institutional problems is severely limited. The government is preoccupied with simply staying in power and maintaining peace in the cities. Leadership and administrative ability in rural areas are sadly lacking. Bureaucratic red tape discourages progress. Those reluctant to delegate responsibility are complemented by those reluctant to accept it. The sheer size of the problems and the limitations imposed by the resources available stifle change.

**Production Shortfall in 1985**

65. To forecast Bangladesh's 1985 foodgrain demand and production, a linear difference equation simulation model was developed. Several values of the

5. As of 1 November 1974, the official exchange rate was 8.13 takas to US $1.

production and population growth rates were used in the simulation. A description of the model is contained in the Appendix.

66. During the period FY 1950-74, Bangladesh's foodgrain production grew at an annual trend rate of 2.2%.[6] For estimating future growth, however, the period FY 1971-74 was omitted because the disruptions resulting from Bangladesh's independence struggle are assumed to have been a one-time occurrence. In the period FY 1950-70, the growth trend for foodgrain production was 2.6% a year. During the 1950s, neglect of East Pakistan in general and its agriculture in particular is reflected in a 0.6% yearly growth trend of foodgrain output. The growth trend in the 1960s increased to 2.7%. Although weather conditions are the most important factor in foodgrain production in any one year, projections of production over the long term can with impunity assume a normal distribution of weather variations. While this assumption is not valid for many regions of the world, there is at present no convincing evidence that the dimensions of the annual monsoon are dependent on weather conditions of previous years. Changes in government policy, however, can have a profound effect on the growth of the agricultural sector. Therefore, five alternative growth trend rates for foodgrain production are used -- each rate implying different assumptions about expansion of acreage and yield increases from the FY 1974 data base -- and are shown in the accompanying tabulation. While all these estimates of future growth of foodgrain production are within Bangladesh's ability, a range of 2.5% to 3.0% is most likely without some drastic change in the resources and priority accorded to agriculture by the government.

| Percent | | |
|---|---|---|
| Pro-duction | Area | Average Yields |
| 2.0 | 0.4 | 1.6 |
| 2.5 | 0.5 | 2.0 |
| 3.0 | 0.6 | 2.4 |
| 3.5 | 0.7 | 2.8 |
| 4.0 | 0.8 | 3.2 |

67. In estimating demand for foodgrains in 1985, population growth and changes in per capita income are considered. Because disagreement exists on Bangladesh's present population growth rate, both 3.09% and 3.3% are used -- the former being the official estimate of the Bangladesh government and the latter being closer to that generally accepted by demographers. These growth rates yield mid-1985 populations of 113 million and 115 million, respectively.

68. Change in per capita income is estimated from two sets of data. First, to estimate future GNP, the past growth rates of real GDP for East Pakistan during

6. All trend rates are calculated by fitting an exponential regression curve and are therefore estimates of the trend of production rather than absolute production growth rates. By emphasizing the trend of production instead of the magnitude of increase, the rates presented are more relevant to future projections.

several periods were examined. During the period FY 1950-70, the growth trend rate of real GDP was 3.0%, with a similar acceleration in the trend rate in the latter decade -- the trend rate for the 1950s was 1.5% and for the 1960s, 4.3%. Second, recognizing that foodgrain production is a major determinant of GDP, a linear correlation was made to determine the influence that changes in foodgrain production had on changes in GDP.[7] Only the period FY 1950-70 was used because data on Bangladesh's GDP since independence are unavailable. The growth rates of real GDP that correspond to assumed growth rates of foodgrain production are given in Table 7.

**Table 7**

**Bangladesh: Projected Foodgrain Situation in FY 1985**

| Annual Growth Rates (Percent) | | | Output (Million Metric Tons) | | |
|---|---|---|---|---|---|
| Population ($\beta$) | Foodgrain Production ($\alpha$) | Real GDP ($\gamma$) | Foodgrain Demand ($T_t$) | Foodgrain Production ($F_t$) | Gap |
| 3.09 | 2.0 | 2.99 | 19.6 | 14.9 | 4.7 |
| 3.09 | 2.5 | 3.14 | 19.7 | 15.8 | 4.0 |
| 3.09 | 3.0 | 3.28 | 19.8 | 16.6 | 3.2 |
| 3.09 | 3.5 | 3.43 | 19.9 | 17.5 | 2.4 |
| 3.09 | 4.0 | 3.58 | 20.1 | 18.5 | 1.6 |
| 3.3 | 2.0 | 2.99 | 19.9 | 14.9 | 5.0 |
| 3.3 | 2.5 | 3.14 | 20.0 | 15.8 | 4.2 |
| 3.3 | 3.0 | 3.28 | 20.1 | 16.6 | 3.5 |
| 3.3 | 3.5 | 3.43 | 20.2 | 17.5 | 2.7 |
| 3.3 | 4.0 | 3.58 | 20.4 | 18.5 | 1.9 |

69. The ranges of projected growth rates of foodgrain production and population growth rates yield a gap between production and demand in 1985 that varies from 1.6 million to 5.0 million tons. However, assuming present government policy remaining basically unchanged, the more likely range of growth rates for foodgrain production of 2.5% to 3.0% yields a gap of 3.2 million to 4.2 million tons. The reaction of the government to the strains that such gaps would entail will determine whether they are allowed to develop. It is likely that persistent gaps in excess of 3 million tons would lead to a sharp altering of priorities in favor of agriculture and a reduction of the gap by 1985.

7. Equation 4 in the Appendix.

**Financing Development and Grain Imports**

70. Economic activity in Bangladesh still has not fully recovered from the 1971 independence struggle. Progress has fallen far short of plans. The Five-Year Plan is faltering. Development allocations in all sectors have been greatly reduced by inflation -- now running at about 20% a year. Additional revenue will be difficult to raise. Farm income, the major potential source of new revenue, remains virtually untaxed, and there is considerable political resistance to taxing it. Funds for agricultural development will remain scarce.

71. Worldwide increases in prices for petroleum, fertilizer, and foodgrain have greatly aggravated Bangladesh's chronic balance-of-payments problems. These three imports alone will just about equal this year's expected export earnings of about $600 million -- some foodgrain and fertilizer imports, however, will come in under aid agreements. Imports of raw materials and spare parts are needed to increase industrial production and exports. Exports cannot finance increased import costs, because export prices are increasing much more slowly than import prices. Chronic balance-of-payments strictures are likely to continue. Bangladesh will be unable to pay for increased foodgrain imports without more foreign aid.

## Appendix

### Bangladesh Foodgrain Model

The model is described as follows:

(1) $$F_{t+1}=F_t\left(\frac{1+\alpha}{100}\right)$$

(2) $$P_{t+1}=P_t\left(\frac{1+\beta}{100}\right)$$

(3) $$G_{t+1}=G_t\left(\frac{1+\gamma}{100}\right)$$

(4) $$\gamma=2.39386+(0.29698)\alpha$$

(5) $$I_t=\frac{G_t}{P_t}$$

(6) $$D_t=aI_t^{0.35}$$

(7) $$T_t=D_tP_t$$

where

$\alpha$ = Growth rate of foodgrain production (percent)
$\beta$ = Growth rate of population (percent)
$F_t$ = Foodgrain production in time t (metric tons)
$P_t$ = Population in time t (people)
$G_t$ = Gross domestic production in time t (takas)
$\gamma$ = Growth rate of gross domestic product (percent)
$I_t$ = Gross domestic product per capita in time t (takas per person)
$a$ = a constant (metric tons per unit of value)

and initial values are:

$\alpha$ = 2.0, 2.5, 3.0, 3.5, and 4.0
$\beta$ = 3.09 and 3.3
$F_0=12.01\times10^6$ metric tons
$P_0=79.6\times10^6$ people
$I_0$ = 858 takas/person
$D_0$ = 0.177 metric ton/person
$G_0=6.35\times10^{10}$ takas

The basic assumptions of the model are:

a. The growth rate of foodgrain production is an exogenous variable. Several values, based upon historical data and judgments of realizable potential, are used.

b. The growth rate of population is an exogenous variable.

c. The growth rate of gross domestic product (GDP) is a linear function of the growth rate of foodgrain production.